526 Rec'd PCT/PTO 20 DEC 2000

FORM PTO-1390 REV. 5-93 US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEYS DOCKET NUMBER **P00,1921** U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/720144
INTERNATIONAL APPLICATION NO. **PCT/DE99/01814**	INTERNATIONAL FILING DATE **22 JUNE 1999**	PRIORITY DATE CLAIMED **22 JUNE 1998**

TITLE OF INVENTION
METHOD FOR DIGITAL RADIO TRANSMISSION OF DATA OF A PLURALITY OF SUBSCRIBERS

APPLICANT(S) FOR DO/EO/US **THEO KREUL, ET AL.**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached.
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2) - drawings attached.

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) **UNSIGNED...**

10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report, 20 References).**

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**

13. ☒ Amendment "A" Prior to Action with Appendix "A" attached.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☒ A substitute specification and a mark-up for substitute specification.

15. ☐ A change of address letter attached to the Declaration.

16. ☒ Other items or information:

    a. ☒ EXPRESS MAIL #EL655302863US dated December 20, 2000.

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U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5) 09/720144	INTERNATIONAL APPLICATION NO PCT/DE99/01814	ATTORNEY'S DOCKET NUMBER P00,1921

				CALCULATIONS	PTO USE ONLY
17. ☒ The following fees are submitted: **BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):** Search Report has been prepared by the EPO or JPO . . . . $860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) . . $690.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) . . . . $710.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO . . . . $1000.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) . . . . $ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	07 - 20 =	0	X $ 18.00	$	
Independent Claims	01 - 3 =	0	X $ 80.00	$	
Multiple Dependent Claims			$270.00 +	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)				$	
SUBTOTAL =				$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +					
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be refunded	$
				charged	$

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ____________ in the amount of $ ________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1519. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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Registration Number

BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

APPLICANT(S):	THEO KREUL, ET AL.
ATTORNEY DOCKET NO.:	P00,1921
INTERNATIONAL APPLICATION NO:	PCT/DE99/01814
INTERNATIONAL FILING DATE:	22 JUNE 1999

INVENTION: METHOD FOR DIGITAL RADIO TRANSMISSION OF DATA OF A PLURALITY OF SUBSCRIBERS

Assistant Commissioner for Patents,
Washington D.C. 20231

AMENDMENT A PRIOR TO ACTION

Sir:

Applicants herewith amend the above-referenced PCT application, and request entry of the Amendment prior to examination on the United States Examination Phase.

IN THE CLAIMS:

On substitute page 9:

replace line 1 with --WHAT IS CLAIMED IS:--;

Please replace original claims 1-7 with the following rewritten claims 1-7, referring to the mark-ups in Appendix A.

1. (Amended) A method for digital radio transmission of data between a base station and a plurality of subscribers in time slot frames, comprising the steps of:

transmitting payload data of a plurality of different subscribers in one time slot; and

defining, by a position of said payload data in a time slot, a corresponding subscriber.

Appendix A
Mark Ups for Claim Amendments

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between -
original document : C:\WINDOWS\DESKTOP\MY BRIEFCASE\P001921-KREUL-DIGITAL RADIO TRANSMISSION\PRE COMPARE CLAIMS.DOC
and revised document: C:\WINDOWS\DESKTOP\MY BRIEFCASE\P001921-KREUL-DIGITAL RADIO TRANSMISSION\AMENDED CLAIMS.DOC

CompareRite found 29 change(s) in the text

Deletions appear as Overstrike text surrounded by []
Additions appear as Bold text

1. [~~Met hod~~]**(Amended) A method** for digital radio transmission of data between a base station and a plurality of subscribers in time slot frames, [~~whereby the~~]**comprising the steps of:**

transmitting payload data of a plurality of different subscribers [~~are transmitted~~] in one time slot[~~, characterized in that the~~]**; and**
defining, by a position of [~~the~~] **said** payload data in a time slot [~~defines the~~]**, a** corresponding subscriber.

2. [~~Method~~]**(Amended) The method** according to claim 1, [~~characterized in that the~~]**further comprising the step of interleaving, symbol-by-symbol,** data symbols of various subscribers [~~are~~] transmitted within a time slot [~~interleaved symbol-by-symbol.~~]**.**

[~~3. Method~~] **3. (Amended) The method** according to claim 1, [~~characterized in that the~~]**further comprising the step of interleaving, block-by-block,** data symbols of various subscribers [~~to be transmitted are~~] transmitted within a time slot [~~interleaved block-by-block.~~]**.**

[~~4. Method~~] **4. (Amended) The method** according to claim 3, [~~characterized in the~~] **wherein** data symbol blocks of subscribers who require a higher transmission quality are transmitted [~~in the proximity of~~] **near** a synchronization training sequence.

5. [~~Method according to one of the claims 1 through 4, characterized in that the~~]**(Amended) The method according to claim 1, further comprising the step of transmitting said** data symbols of various subscribers to be transmitted [~~are transmitted~~] encoded with a spread code.

6. ~~[Method]~~**(Amended) The method** according to claim 5, ~~[characterized in that]~~ **further comprising the step of employing** a plurality of orthogonal spread codes having variable length ~~[are employed]~~ for ~~[the]~~ **a** simultaneous transmission of ~~[the]~~ data symbols of a plurality of subscribers.

7. ~~[Method]~~**(Amended) The method** according to claim 6, ~~[characterized in that the]~~ **wherein** elements of ~~[the]~~ **said** orthogonal spread ~~[code]~~ **codes** lie on ~~[the]~~ **a** unit circle in the complex number plane.

4|PRTS

09/720144
529 Rec'd PCT/PTO 20 DEC 2000

SPECIFICATION

TITLE

METHOD FOR DIGITAL RADIO TRANSMISSION OF DATA OF A PLURALITY OF SUBSCRIBERS

BACKGROUND OF THE INVENTION

Field of the Invention

The invention is directed to a method for frame-oriented transmission of the subscriber data of a plurality of subscribers.

Description of the Related Art

The digital cordless transmission of data for voice communication, cordless fax, or computer applications has encountered broad acceptance in the framework of installing area-covering, cellular digital mobile radio telephone networks. Three methods are fundamentally known for dividing the available transmission bandwidth within a communication cell onto the individual subscribers. In TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) methods, the data of various subscribers are transmitted in different time slots in time-division multiplex. In FDMA (**F**requency **D**ivision **M**ultiple **A**ccess) methods, subscribers are divided onto different frequency bands, and, in CDMA (**Co**de **D**ivision **M**ultiple **A**ccess) methods, the data of different subscribers are encoded with different codes. In practice, combinations of two of these methods are often employed. The mobile telephone standard GSM (Global System for Mobile Communications) that is used internationally in many countries employs, for example, a combination of TDMA and FDMA. Below, the GSM air interface, i.e., the transmission protocol for the radio signal transmission, is explained in brief on the basis of Figure 1 by way of example. The GSM networks operated in Germany and in most European countries work in two transmission bands between 890 and 915 MHz and 935 and 960 MHz. However, it is also possible to select a different frequency. For example, the DCS-1800 system likewise works according to the GSM standard in a frequency range of 180 MHz (E-networks).

In the GSM system, for example, 124 channels with a channel spacing of 200 kHz are available for the upstream connection (uplink) and 124 channels having a channel spacing of 200 kHz are likewise available for the downstream direction (downlink; see Figure 1). Each of these frequency channels is in turn divided into time-division multiplex frames or TDMA frames having a duration of 4.615 ms. Each time-division multiplex frame is in turn composed of eight time slots having a duration of 577 μs. On average, each time slot contains a training sequence for synchronization, preamble data or postamble data at the beginning and at the end of the time slot as well as a guard period between two neighboring time slots (bursts). Others, for example, are described in (David, Benker, "Digitale Mobilfunksystems", Stuttgart, 1994, pages 326 through 362).

For each subscriber in a mobile radio cell, one respective time slot in one of the 124 channels is required for the upstream connection and one time slot is required for the downstream connection. One disadvantage of this method is that a fixed transmission capacity of a time slot per transmission frame is allocated to each subscriber which is often not utilized.

United States patent no. 5,193,091 discloses a TDMA telecommunication system in which messages are transmitted via radio channels between pico-cellular, mobile radio transmission / radio reception devices allocated to distributed pico-cells and micro-cellular, mobile radio transmission / radio reception devices allocated to micro-cell encompassing the pico-cells. These radio channels are subdivided into time slots, in which at least one of the time slots is in turn subdivided into sub-time slots, so that micro-cellular radio transmission / radio reception devices transmit messages within the time slots and pico-cellular radio transmission / radio reception devices transmit messages in the sub-time slots, where the individual sub-time slots are respectively allocated to the individual pico-cells.

SUMMARY OF THE INVENTION

The invention is therefore based on the object of providing a method for digital radio transmission of data between a base station and a plurality of subscribers, in which the transmission capacity can be flexibly divided onto various

users with different data rates, for example, voice communication or data communication.

This object is achieved by a method for digital radio transmission of data between a base station and a plurality of subscribers in time slot frames, comprising the steps of transmitting payload data of a plurality of different subscribers in one time slot; and defining, by a position of said payload data in a time slot, a corresponding subscriber.

Advantageous developments include interleaving, symbol-by-symbol, data symbols of various subscribers transmitted within a time slot or interleaving, block-by-block, data symbols of various subscribers transmitted within a time slot. Data symbol blocks of subscribers who require a higher transmission quality may be transmitted near a synchronization training sequence. Data symbols of various subscribers to be transmitted may be encoded with a spread code, and one may employ a plurality of orthogonal spread codes having variable length for a simultaneous transmission of data symbols of a plurality of subscribers. Elements of such orthogonal spread codes may lie on a unit circle in the complex number plane.

In the inventive method, the data to be transmitted between a plurality of different subscribers and the base station are transmitted in time slot frames, in which the position of the data in time slot identifies the corresponding subscriber. On the basis of the position of a detected data symbol within a time slot received by the receiver, the subscriber recognizes whether the symbol belongs to the data sequence allocated to him. Conversely, the base station determines the subscriber or, respectively, the mobile part from which the data are transmitted based on the position of detected data symbol. This is thus a matter of a second time-division multiplex stage within a time frame. The length of these time-division multiplex data packets, however, is variable in contrast to those of the TDMA frame.

The data of the various subscribers can be transmitted interleaved by symbols or by blocks within a time frame. For block-by-block interleaving, subscribers who require a high transmission quality, for example, for a data communication, can be transmitted in the proximity of a synchronization training sequence. The time-varying multiple path propagation paths are estimated with the

assistance of a training or pilot sequence and allow a very good prediction of the distortions caused by the channel for data symbols arranged in their immediate proximity. A higher dependability of detection can thus be achieved for these data symbols than for data symbols arranged at a greater distance therefrom.

An advantageous development of the inventive method derives when applied in CDMA-based systems with variable spread code length. The data symbols to be transmitted are transmitted encoded with a spread code. As a result of an adaptation of the spread code length, an adaptation to the data symbol rate requested by the subscriber can result for a constantly prescribed chip rate of the transmission system (given a constant transmission bandwidth).

In these CDMA systems, a plurality of orthogonal spread codes of variable length are preferably employed for a simultaneous transmission of the data symbols of a plurality of subscribers. Orthogonal spread codes can be easily separated by the receiver. A total of n orthogonal spread codes given a length of n symbols are thus available, so that the bandwidth available can be optimally utilized despite frequency spreading. The elements of the orthogonal spread code can, for example, lie on the unit circle in the complex number plane.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained below on the basis of the appertaining drawings.

Fig. 1 is a schematic diagram showing the known GSM air interface;

Fig. 2 is a structure diagram schematically showing a TDMA time slot of the inventive method;

Fig. 3 is a structure diagram schematically showing a spread-encoded CDMA/TDMA time slot of the inventive method; and

Fig. 4 is a block diagram of the transmission path between transmitter and receiver in the inventive radio transmission method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

By way of example, Fig. 2 shows a time-division multiplex TDMA frame with eight time slots. The invention, however, is not limited to a specific arrangement of the time slots or time-division multiplex frames. A time slot can contain the following components: data bits, preamble, midamble, post amble and a protection band or guard (GP). In the GSM system, a training sequence is provided as a midamble. The training sequence or pilot sequence, however, can also be arranged in another area of the time slot. In the inventive, digital radio transmission method, a time slot comprises at least one data region. This is in turn divided into blocks composed of a plurality N of transmission data symbols of various subscribers. In the example shown in Fig. 2, the data symbols or data bits of four subscribers are arranged in one data block.

There are two different possibilities for the arrangement of the data symbols of a plurality of subscribers within a time slot:

1. Complete Interleaving:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with double the data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 5, 9, 13... N-3.

Subscriber 2 occupies the transmission data symbols 3, 7, 11, 15...N-1.

Subscriber 3 occupies the transmission data symbols 2, 4, 6, 8, 10, 12, 14, 16, ... N-2, N.

2. Block Formation:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 2, 3,...N/4

Subscriber 2 occupies the transmission data symbols N/4+1, N/4+2,...N/2.

Subscriber 3 occupies the transmission data symbols N/2+1, N/2+2,...N.

It is clear from the examples that the data capacity can be optimally utilized by the simultaneous utilization of a data block in a time slot by a plurality of subscribers. At the same time, the available transmission capacity can be flexibly

allocated. In the above examples, a data rate that is double the data rate of the subscribers 1 and 2 is allocated to the subscriber 3.

The position of the individual data symbols or data blocks within the time slot indicates the respective subscriber. This information can be accommodated in a control signal field in a preamble area, postamble area or the like of the time slot. For the subscribed, block-by-block arrangement of the data symbols of various subscribers, the data of subscribers that require an especially high transmission quality can be arranged in the proximity of the training sequence (for example, subscriber 1 in the example of Fig. 2). The time-variable multi-path propagation paths are estimated with the assistance of a training or pilot sequence and allow a very good prediction of the distortions caused by the channel for the data symbols arranged in its immediate proximity. A higher dependability of the detection can thus be achieved for these data symbols than for data symbols arranged at a greater distance. This effect is initially independent of the selected detector, as long as it involves the estimate of the channel properties.

The application of the invention to CDMA-based systems with spread encoding of variable spread code length is explained in greater detail below on the basis of examples and with reference to Fig. 3. In order to also be able to advantageously use the inventive transmission method in which the data symbols of a plurality of subscribers are transmitted in one time slot, when the currently required data rate lies below the maximum transmission capacity, a spread of the data symbols with a spread code having a defined length of n symbols can be undertaken. In a TDMA time slot, a CDMA division is also undertaken in addition to the time-division multiplex blocks or chips. In the example shown in Fig. 3, the data of nine different subscribers are thus transmitted in 24 blocks (six time-division mulitplex blocks times four different spread codes) in one TDMA time slot, where between one block (subscribers 8 and 9) and four blocks (subscriber 7) are allocated to the respective subscribers. The radio transmission is less sensitive to narrow-band interference within the transmission frequency band. The transmission is only deteriorated but a total outage does not occur. Due to an adaptation of the spread code length, an adaptation to the data symbol rate requested by the subscriber can

be achieved for a constantly predetermined chip rate of the transmission system (given constant transmission band width). For a high user data rate, the spread code length is reduced and, thus, a data symbol of the user is transmitted with a lower number of chips. In order to achieve the same energy per payload bit, the transmission power is increased by the corresponding factor. For a low payload data rate of the subscriber, the spread code length is increased and the power is reduced.

When a plurality of orthogonal spread codes are used that can be easily separated by the receiver, the transmission bandwidth available is utilized in the best possible way, since a total of n orthogonal spread codes with which the data symbols of various subscribers can be transmitted in parallel are available for a spread code length of n symbols. The allocation of the data symbols to the respective subscribers takes place both on the basis of the position of the symbols or symbol blocks within a time slot as well as on the basis of the respectively selected spread code. A plurality of subscriber data streams can be simultaneously communicated in parallel with spread codes of different length that, however, are orthogonal relative to one another.

In a TDMA system, the introduction of the variable spread can avoid a pulsed mode at very low user data rates. Due to the spread, each user bit is distributed onto a plurality of "chips" and enables the interruption-free emission of the chip symbols with the predetermined clock rate of the transmission channel. The transmission power can also be reduced by the spread factor in this situation.

Three examples of the inventive method with spread encoding are explained below. The spread code or CDMA code in the examples is composed of four symbols (1, j, -1, -j in the first and second example, where j = o-1). Each subscriber data symbol (bit) is expanded by the code spreading, i.e., multiplication with the spread code symbols, being expanded onto a "chip" composed of four symbols.

Example (1): Q=4, 1 User

<table>
<tr><td>Chip No.</td><td>1|2|
3|4|</td><td>5|6|
7|8|</td><td>9|10|1
1|12|</td><td>13|14|1
5|16|</td><td>17|18||
19|20|</td><td>21|22|
23|24|</td><td></td></tr>
<tr><td>CDMA-
Code</td><td>1 j -1
-j</td><td>1 j -1
-j</td><td>1 j -1 -j</td><td>1 j -1 -j</td><td>1 j -1 -j</td><td>1 j -1 -j</td><td>**
*</td></tr>
<tr><td>User
Data</td><td>1st bit</td><td>2nd bit</td><td>3rd bit</td><td>4thbit</td><td>5th bit</td><td>6th bit</td><td>**
*</td></tr>
</table>

Example (2): Q=4, Number of users = 2

<table>
<tr><td>Chip No.</td><td>1|2|
3|4|</td><td>5|6|
7|8|</td><td>9|10|1
1|12|</td><td>13|14|1
5|16|</td><td>17|18||
19|20|</td><td>21|22|
23|24|</td><td></td></tr>
<tr><td>CDMA-
Code</td><td>1 j -
1 -j</td><td>1 j -
1 -j</td><td>1 j -1
-j</td><td>1 j -1 -j</td><td>1 j -1 -j</td><td>1 j -1 -
j</td><td>**
*</td></tr>
<tr><td>User Data</td><td>1:1</td><td>2:1</td><td>1:2</td><td>2:2</td><td>1:3</td><td>2.3</td><td>**
*</td></tr>
</table>

SUBSTITUTE SPECIFICATION

Example (3): Q = 4, Number of Users = 6, Number of CDMA codes = 3

<table>
<tr><td>Chip No.</td><td>1|2|
3|4|</td><td>5|6|7
|8|</td><td>9|10|1
1|12|</td><td>13|14|
15|16|</td><td>17|18|1
9|20|</td><td>21|22|2
3|24|</td><td></td></tr>
<tr><td>CDMA-
Code</td><td>1 j -
1 -j</td><td>1 j -
1 -j</td><td>1 j -1
-j</td><td>1 j -1 -
j</td><td>1 j -1 -j</td><td>1 j -1 -j</td><td>***</td></tr>
<tr><td>User
Data</td><td>1:1</td><td>4:1</td><td>1:2</td><td>4:2</td><td>1:3</td><td>4.3</td><td>***</td></tr>
<tr><td>CDMA-
Code2</td><td>1 j
1 j</td><td>1 j 1
j</td><td>1 j 1
j</td><td>1 j 1
j</td><td>1 j 1 j</td><td>1 j 1 j</td><td></td></tr>
<tr><td>Data
Symbols</td><td>2:1</td><td>5:1</td><td>2:2</td><td>5:2</td><td>2:3</td><td>5:3</td><td></td></tr>
<tr><td>CDMA-
Code 3</td><td>1 -j
-1 -j</td><td>1 -j
-1 -j</td><td>1 -j
-1 -j</td><td>1 -j -
1 j</td><td>1 -j -1
j</td><td>1 -j -
1 j</td><td></td></tr>
<tr><td>Data
Symbols</td><td>3:1</td><td>6:1</td><td>3:2</td><td>6:2</td><td>3:3</td><td>6:3</td><td></td></tr>
</table>

In the first example, the data symbols (first bit, second bit, etc.) of only one subscriber are transmitted in the data section of the time slot. The bits are successively multiplied by the spread code (1, j, -1, -j) and are less expanded onto four symbols that respectively form a chip that is then transmitted.

Two subscribers are present in the second example. The data symbols are respectively multiplied by the same spread code and are transmitted in alternation at successive positions within a time slot as expanded chip.

In the third example, a total of six subscribers are present. In order to offer an adequate transmission capacity, a total of three orthogonal spread codes or CDMA codes are employed. Two codes are orthogonal when their products yields zero. This results in the chips of different subscribers generated with orthogonal codes being easily separated. In Example 3, the spread code (1, j, -1, -j) is used for the subscribers 1 and 4, the code (1, j, 1, j) is used for the subscribers 2 and 5, and the code (1, -j,-1, j) is used for the subscribers 3 and 6. The data of the six subscribers can thus be transmitted spread and time-multiplexed in the time slot. Symbols of four orthogonal codes exist for a code having the length n = 4, so that four times the data quantity compared to the unspread data transmission can be transported in one time slot frame for four times the bandwidth.

Figure 4 shows a schematic block diagram of the transmission path of a digital radio transmission method with reference to the example of voice communication. A voice activity detector 1 detects whether the subscriber is speaking and activates or deactivates the radio-frequency transmitter 11 in corresponding conformity. The voice signal is encoded by the encoders 1, 3, 4, and the bits are arranged in the bit reordering mechanism 5. The data are spread-encoded in the spread encoder 6, are interleaved with the interleavers 7 and are encrypted with the encrypter 8. The encoded, interleaved and encrypted data symbols are ordered within the data region of the time slot in the time slot assembler (burst assembler) 9. Additionally, the position information is attached to a section of the time slot. The data are modulated by the GMSK modulator and are transmitted from the RF transmitter 11 via the channel 20 to the RF receiver 11', are demodulated by the GMSK demodulator and equalizer 10'. The time slots or bursts are resolved by the burst resolver/disassembler 9', the data acquired in this way are deciphered by the deciphering mechanism/decrypter 8' and are de-interleaved by the de-interleaver 7' . With the assistance of an inverse spread code, the data are decoded by the spread decoder circuit 6', the bits are arranged and the data are

decoded by the decoders 1'; 3' and 4'. A noise suppression 12 can be provided for voice communication.

The invention provides a digital radio transmission method in which the data symbols of a plurality of different subscribers are transmitted within a time slot of a time-division multiplex frame, where the position of the data identifies the corresponding subscriber. This enables a flexible allocation of transmission capacity to the subscribers. In one development of the inventive method, the data symbols of the various subscribers are encoded with a variable-length spread code and are thus transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

The above-described method is illustrative of the principles of the present invention. Numerous modifications and adaptations thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

ABSTRACT

In a method for radio transmission of data of a plurality of subscribers in a time-division multiplex manner, the data of a plurality of different subscribers are transmitted in one time slot of a time-division multiplex frame, the position of the data in a time slot identifying the corresponding subscriber. This results in a flexible allocation of the transmission capacity. Additionally, the data symbols can be encoded with a variable-length spread code and can thus be transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between - original document : Q:\DOCUMENTS\YEAR 2000\P001921-KREUL-DIGITAL RADIO TRANSMISSION\PRE COMPARE SPEC.DOC and revised document: Q:\DOCUMENTS\YEAR 2000\P001921-KREUL-DIGITAL RADIO TRANSMISSION\SUBSTITUTE SPECIFICATION.DOC

CompareRite found 94 change(s) in the text

Deletions appear as Overstrike text surrounded by []
Additions appear as Bold-Underline text

SPECIFICATION

TITLE

METHOD FOR DIGITAL RADIO TRANSMISSION OF DATA OF A PLURALITY OF SUBSCRIBERS

BACKGROUND OF THE INVENTION

Field of the Invention

The invention is directed to a method for frame-oriented transmission of the subscriber data of a plurality of subscribers.

Description of the Related Art

The digital cordless transmission of data for voice communication [~~or~~]**,** cordless fax**,** or computer applications has encountered broad acceptance in the framework of installing area-covering, cellular digital mobile radio telephone networks. Three methods are [~~thereby~~] fundamentally known for dividing the available transmission bandwidth within a communication cell onto the individual subscribers. In TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) methods, the data of various subscribers are transmitted in different time slots in time-division multiplex. In FDMA (**F**requency **D**ivision **M**ultiple **A**ccess) methods, subscribers are divided onto different frequency bands, and, in CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) methods, the data of different subscribers are encoded with different codes. In practice, combinations of two of these methods are often employed. The mobile telephone standard GSM (Global System for Mobile Communications) that is used internationally in many countries employs, for example, a combination of TDMA and FDMA. Below, the GSM air interface, i.e.**,** the transmission protocol for the radio signal transmission, is explained in brief on the basis of Figure 1 by way of example. The GSM networks

operated in Germany and in most European countries work in two transmission bands between 890 and 915 MHz and 935 and 960 MHz. However, it is also possible to select a different frequency. For example, the DCS-1800 system likewise works according to the GSM standard in a frequency range of 180 MHz (E-networks).

In the GSM system, for example, 124 channels with a channel spacing of 200 kHz are available for the upstream connection (uplink) and 124 channels having a channel spacing of 200 kHz are likewise available for the downstream direction (downlink; see Figure 1). Each of these frequency channels is in turn divided into time-division multiplex frames or TDMA frames having a duration of 4.615 ms. Each time-division multiplex frame is in turn composed of eight time slots having a duration of 577 μs. On average, each time slot contains a training sequence for synchronization, preamble data or~~[, respectively,]~~ postamble data at the beginning and at **the** end of the time slot as well as a guard period between two neighboring time slots (bursts). Others, for example, are described in (David, Benker, "Digitale Mobilfunksystems", Stuttgart, 1994, pages 326 through 362**)**.

For each subscriber in a mobile radio cell, ~~[respectively one]~~**one respective** time slot in one of the 124 channels is required for the upstream connection and one time slot is required for the downstream connection. One disadvantage of this method is ~~[comprised therein]~~ that a fixed transmission capacity of a time slot per transmission frame is allocated to each subscriber~~[, this]~~ **which is** often not ~~[being]~~ utilized.

~~[US]~~ **United States patent no.** 5,193,091 discloses a TDMA telecommunication system ~~[wherein]~~ **in which** messages are transmitted via radio channels between pico-cellular, mobile radio transmission / radio reception devices allocated to distributed pico-cells and micro-cellular, mobile radio transmission / radio reception devices allocated to micro-cell encompassing the pico-cells~~[, said]~~**. These** radio channels ~~[being]~~ **are** subdivided into time slots, ~~[whereby]~~ **in which** at least one of the time slots is in turn subdivided into sub-time slots, so that micro-cellular radio transmission / radio reception devices transmit messages within the time slots and pico-cellular radio transmission / radio reception devices transmit messages in the sub-time slots, ~~[whereby]~~ **where** the individual sub-time slots are respectively

allocated to the individual pico-cells.

SUMMARY OF THE INVENTION

The invention is therefore based on the object of [~~composing~~] **providing** a method for digital radio transmission of data between a base station and a plurality of subscribers, [~~whereby~~] **in which** the transmission capacity can be flexibly divided onto various users with different data rates, for example**,** voice communication or data communication.

This object is achieved by [~~the~~] **a method for** digital radio transmission [~~method defined in claim 1. Advantageous developments of the invention are described in the subclaims.~~] **of data between a base station and a plurality of subscribers in time slot frames, comprising the steps of transmitting payload data of a plurality of different subscribers in one time slot; and defining, by a position of said payload data in a time slot, a corresponding subscriber.**

Advantageous developments include interleaving, symbol-by-symbol, data symbols of various subscribers transmitted within a time slot or interleaving, block-by-block, data symbols of various subscribers transmitted within a time slot. Data symbol blocks of subscribers who require a higher transmission quality may be transmitted near a synchronization training sequence. Data symbols of various subscribers to be transmitted may be encoded with a spread code, and one may employ a plurality of orthogonal spread codes having variable length for a simultaneous transmission of data symbols of a plurality of subscribers. Elements of such orthogonal spread codes may lie on a unit circle in the complex number plane.

In the inventive method, the data to be transmitted between a plurality of different subscribers and the base station are transmitted in time slot frames, [~~whereby~~] **in which** the position of the data in time slot identifies the corresponding subscriber. On the basis of the position of a detected data symbol within a time slot received by the receiver, the subscriber recognizes whether the symbol belongs to the data sequence allocated to him. Conversely, the base station determines the subscriber or, respectively, the mobile part from which the data are transmitted based on the position of detected data symbol. This is thus a matter of a second

time-division multiplex stage within a time frame. The length of these time-division multiplex data packets, however, is variable in contrast to those of the TDMA frame.

The data of the various subscribers can be transmitted interleaved by symbols or by blocks within a time frame. [~~Given~~] **For** block-by-block interleaving, subscribers who require a high transmission quality, for example, for a data communication, can be transmitted in the proximity of a synchronization training sequence. The time-varying multiple path propagation paths are estimated with the assistance of a training or pilot sequence and allow a very good prediction of the distortions caused by the channel for data symbols arranged in their immediate proximity. A higher dependability of detection can thus be achieved for these data symbols than for data symbols arranged at a greater distance therefrom.

An advantageous development of the inventive method derives [~~given application~~] **when applied** in CDMA-based systems with variable spread code length. The data symbols to be transmitted are [~~thereby~~] transmitted encoded with a spread code. As a result of an adaptation of the spread code length, an adaptation to the data symbol rate requested by the subscriber can [~~achieve given~~] **result for** a constantly prescribed chip rate of the transmission system (given a constant transmission bandwidth).

In these CDMA [~~system~~] **systems**, a plurality of orthogonal spread codes of variable length are preferably employed **for a** simultaneous transmission of the data symbols of a plurality of subscribers. Orthogonal [~~spectrodes~~] **spread codes** can be easily separated by the receiver. A total of n orthogonal spread codes given a length of n symbols are thus available, so that the bandwidth available can be optimally utilized despite frequency spreading. The elements of the orthogonal spread code can, for example, lie on the unit circle in the complex number plane.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is explained below on the basis of the appertaining [~~drawing wherein~~] **drawings.**

Fig. 1 [~~schematically shows~~] **is a schematic diagram showing** the known GSM air interface;

Fig. 2 **is a structure diagram** schematically [~~shows~~] **showing** a TDMA time slot of the inventive method;

Fig. 3 **is a structure diagram** schematically [~~shows~~] **showing** a spread-encoded CDMA/TDMA time slot of the inventive method; and

Fig. 4 is a block diagram of the transmission path between transmitter and receiver in the inventive radio transmission method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

By way of example, Fig. 2 shows a time-division multiplex TDMA frame with eight time slots. The invention, however, is not limited to a specific arrangement of the time slots or time-division multiplex frames. A time slot can contain the following components: data bits, preamble, midamble, post amble and a protection band or guard[~~,~~] (GP). In the GSM system, a training sequence is provided as **a** midamble. The training sequence or pilot sequence, however, can also be arranged in another area of the time slot. In the inventive, digital radio transmission method, a time slot comprises at least one data region. This is in turn divided into blocks composed of a plurality N of transmission data symbols of various subscribers. In the example shown in Fig. 2, the data symbols or data bits of four subscribers are arranged in one data block.

There are two different possibilities for the arrangement of the data symbols of a plurality of subscribers within a time slot:

1. Complete Interleaving:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with double the data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 5, 9, 13... N-3.

Subscriber 2 occupies the transmission data symbols 3, 7, 11, 15...N-1.

Subscriber 3 occupies the transmission data symbols 2, 4, 6, 8, 10, 12, 14, 16, ... N-2, N.

2. Block Formation:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 2, 3,...N/4

Subscriber 2 occupies the transmission data symbols N/4+1, N/4+2,...N/2.
Subscriber 3 occupies the transmission data symbols N/2+1, N/2+2,...N.

It is clear from the examples that the data capacity can be optimally utilized by the simultaneous utilization of a data block in a time slot by a plurality of subscribers. At the same time, the available transmission capacity can be flexibly allocated. In the above examples, **a data rate that is** double the data rate of the subscribers 1 and 2 is allocated to the subscriber 3.

The position of the individual data symbols or data blocks within the time slot indicates the respective subscriber. This information can be accommodated in a control signal field in a preamble area, postamble area or the like of the time slot. ~~[Given]~~ **For** the subscribed, block-by-block arrangement of the data symbols of various subscribers, the data of subscribers that require an especially high transmission quality can be arranged in the proximity of the training sequence (for example, subscriber 1 in the example of Fig. 2). The time-variable multi-path propagation paths are estimated with the assistance of a training or pilot sequence and allow a very good prediction of the distortions caused by the channel for the data symbols arranged in ~~[the]~~ **its** immediate proximity ~~[thereof]~~. A higher dependability of the detection can thus be achieved for these data symbols than for data symbols arranged at a greater distance. This effect is initially independent of the selected detector, as long as it involves the estimate of the channel properties.

The application of the invention to CDMA-based systems with spread encoding of variable spread code length is explained in greater detail below on the basis of examples and with reference to Fig. 3. In order to also be able to advantageously use the inventive transmission method~~[, whereby]~~ **in which** the data symbols of a plurality of subscribers are transmitted in one time slot, when the currently required data rate lies below the maximum transmission capacity, a spread of the data symbols with a spread code having a defined length of n symbols can be undertaken. In a TDMA time slot, a CDMA division is also undertaken in addition to the time-division multiplex blocks or chips. In the example shown in Fig. 3, the data of nine different subscribers are thus transmitted in 24 blocks (six time-division mulitplex blocks times four different spread codes) in one TDMA time slot, ~~[whereby]~~ **where** between one block (subscribers 8 and 9) and four blocks (subscriber 7) are

allocated to the respective subscribers. The radio transmission is less sensitive to narrow-band interference within the transmission frequency band. The transmission is only deteriorated but a total outage does not occur. Due to an adaptation of the spread code length, an adaptation to the data symbol rate requested by the ~~[subscribe]~~ **subscriber** can be achieved ~~[given]~~ **for** a constantly predetermined chip rate of the transmission system (given constant transmission band width). ~~[Given]~~ **For** a high user data rate, the spread code length is reduced and, thus, a data symbol of the user is transmitted with a lower number of chips. In order to achieve the same energy per payload bit, the transmission power is ~~[to be]~~ increased by the corresponding factor. ~~[Given]~~ **For** a low payload data rate of the subscriber, the spread code length is increased and the power is reduced.

When a plurality of orthogonal spread codes are used that can be easily separated by the receiver, the transmission bandwidth available is utilized in the best possible way, since a total of n orthogonal spread codes with which the data symbols of various subscribers can be transmitted in parallel are available ~~[given]~~ **for** a spread code length of n symbols. The allocation of the data symbols to the respective subscribers ~~[thereby ensues]~~ **takes place** both on the basis of the position of the symbols or~~[, respectively,]~~ symbol blocks within a time slot as well as on the basis of the respectively selected spread code. A plurality of subscriber ~~[dat]~~ **data** streams can ~~[thereby]~~ be simultaneously communicated in parallel with spread codes of different length that, however, are orthogonal relative to one another.

In a TDMA system, the introduction of the variable spread can avoid a pulsed mode at very low user data rates. Due to the spread, each user bit is distributed onto a plurality of "chips" and enables the interruption-free emission of the chip symbols with the predetermined clock rate of the transmission channel. The transmission power can also be reduced by the spread factor ~~[here]~~ **in this situation**.

Three examples of the inventive method with spread encoding are explained below. The spread code or CDMA code in the examples is composed of four symbols (1, j, -1, -j in the first and second example, ~~[whereby]~~ **where** j = o-1). Each subscriber data symbol (bit) is expanded by the code spreading, i.e.**,**

multiplication with the spread code symbols, being expanded onto ~~[what is referred to as]~~ a "chip" composed of four symbols.

Example (1): Q=4, 1 User

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18||19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1^{st} bit	2^{nd} bit	3^{rd} bit	4^{th}bit	5^{th} bit	6^{th} bit	***

Example (2): Q=4, Number of users = 2

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18||19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1:1	2:1	1:2	2:2	1:3	2.3	***

Example (3): Q = 4, Number of Users = 6, Number of CDMA codes = 3

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18|19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1:1	4:1	1:2	4:2	1:3	4.3	***
CDMA-Code2	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	
Data Symbols	2:1	5:1	2:2	5:2	2:3	5:3	
CDMA-Code 3	1 -j -1 -j	1 -j -1 -j	1 -j -1 -j	1 -j -1 j	1 -j -1 j	1 -j -1 j	
Data Symbols	3:1	6:1	3:2	6:2	3:3	6:3	

In the first example, the data symbols (first bit, second bit~~(....)~~], etc.) of only one subscriber are transmitted in the data section of the time slot. The bits are successively multiplied by the spread code (1, j, -1, -j) and are less expanded onto four symbols that respectively form a chip that is then transmitted.

Two subscribers are present in the second example. The data symbols are respectively multiplied by the same spread code and are transmitted in alternation at successive positions within a time slot as expanded chip.

In the third example, a total of six subscribers are present. In order to offer an adequate transmission capacity, a total of three orthogonal spread codes or CDMA codes are employed. Two codes are orthogonal when their products yields zero. [~~As a result thereof,~~] **This results in** the chips of different subscribers generated with orthogonal codes [~~can be~~] **being** easily separated. In Example 3, the spread code (1, j, -1, -j) is used for the subscribers 1 and 4, the code (1, j, 1, j) is used for the subscribers 2 and 5, and the code (1, -j,-1, j) is used for the subscribers 3 and 6. The data of the six subscribers can thus be transmitted spread and time-multiplexed in the time slot. [~~Let it be noted that symbols~~] **Symbols** of four orthogonal codes exist [~~given~~] **for** a code having the length n = 4, so that four times the data quantity compared to the unspread data transmission can be transported in one time slot frame [~~given~~] **for** four times the bandwidth.

Figure 4 shows a schematic block diagram of the transmission path of a digital radio transmission method with reference to the example of voice communication. A voice activity detector 1 detects whether the subscriber is speaking and activates or deactivates the radio-frequency transmitter 11 in **corresponding** conformity [~~therewith~~]. The voice signal is encoded by the encoders 1, 3, 4, and the bits are arranged in the [~~means~~] **bit reordering mechanism** 5. The data are spread-encoded in the spread encoder 6, are interleaved with the [~~interleaving means~~] **interleavers** 7 and are encrypted with the [~~encryption means~~] **encrypter** 8. The encoded, interleaved and encrypted data symbols are ordered within the data region of the time slot in the time slot assembler [~~means~~](burst assembler) 9. Additionally, the position information is attached to a section of the time slot. The data are modulated by the GMSK modulator and are transmitted from the RF transmitter 11 via the channel 20 to the RF receiver [~~11~~] **11'**, are demodulated by the GMSK demodulator and equalizer 10'. The time slots or bursts are resolved by the burst [~~resolver means~~] **resolver/disassembler** 9', the data acquired in this way are deciphered by the deciphering [~~means~~] **mechanism/decrypter** 8' and are de-interleaved by the de-[~~interleaving means~~]

interleaver 7' . With the assistance of an inverse spread code, the data are decoded by the spread decoder circuit 6', the bits are arranged and the data are decoded by the decoders 1'; 3' and 4'. A noise suppression ~~[means]~~ 12 can be provided for voice communication.

The invention ~~[proposes]~~ **provides** a digital radio transmission method ~~[wherein]~~ **in which** the data symbols of a plurality of different subscribers are transmitted within a time slot of a time-division multiplex frame, ~~[whereby]~~ **where** the position of the data identifies the corresponding subscriber. This enables a flexible allocation of transmission capacity to the subscribers. In one development of the inventive method, the data symbols of the various subscribers are encoded with a variable-length spread code and are thus transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

~~[ABSTRACT]~~ **The above-described method is illustrative of the principles of the present invention. Numerous modifications and adaptations thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.**

~~[Method For Digital Radio Transmission of Data of a Plurality of Subscribers]~~**ABSTRACT**

In a method for radio transmission of data of a plurality of subscribers in **a** time-division multiplex **manner**, the data of a plurality of different subscribers are transmitted in one time slot of a time-division multiplex frame, ~~[whereby]~~ the position of the data in a time slot ~~[identifies]~~ **identifying** the corresponding subscriber. ~~[As a result thereof,]~~ **This results in** a flexible allocation of the transmission capacity ~~[is realized]~~. Additionally, the data symbols can be encoded with a variable-length spread code and can thus be transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

~~[Figure 3]~~

MARK-UP FOR SUBSTITUTE SPECIFICATION

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1998P01920WOUS
Inventor: Kreul et al.

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METHOD FOR DIGITAL RADIO TRANSMISSION OF DATA OF A PLURALITY OF SUBSCRIBERS

The invention is directed to a method for frame-oriented transmission of the subscriber data of a plurality of subscribers.

The digital cordless transmission of data for voice communication or cordless fax or computer applications has encountered broad acceptance in the framework of installing area-covering, cellular digital mobile radio telephone networks. Three methods are thereby fundamentally known for dividing the available transmission bandwidth within a communication cell onto the individual subscribers. In TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) methods, the data of various subscribers are transmitted in different time slots in time-division multiplex. In FDMA (**F**requency **D**ivision **M**ultiple **A**ccess) methods, subscribers are divided onto different frequency bands, and, in CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) methods, the data of different subscribers are encoded with different codes. In practice, combinations of two of these methods are often employed. The mobile telephone standard GSM (Global System for Mobile Communications) that is used internationally in many countries employs, for example, a combination of TDMA and FDMA. Below, the GSM air interface, i.e. the transmission protocol for the radio signal transmission, is explained in brief on the basis of Figure 1 by way of example. The GSM networks operated in Germany and in most European countries work in two transmission bands between 890 and 915 MHz and 935 and 960 MHz. However, it is also possible to select a different frequency. For example, the DCS-1800 system likewise works according to the GSM standard in a frequency range of 180 MHz (E-networks).

In the GSM system, for example, 124 channels with a channel spacing of 200 kHz are available for the upstream connection (uplink) and 124 channels having a channel spacing of 200 kHz are likewise available for the downstream direction (downlink; see Figure 1). Each of these frequency channels is in turn divided into time-division multiplex frames or TDMA frames having a duration of 4.615 ms. Each time-division multiplex frame is in turn composed of eight time slots having a duration of 577 μs. On average, each time slot contains a training sequence for

528 Rec'd PCT/PTO 20 DEC 2000

synchronization, preamble data or, respectively, postamble data at the beginning and at end of the time slot as well as a guard period between two neighboring time slots (bursts). Others, for example, are described in (David, Benker, "Digitale Mobilfunksystems", Stuttgart, 1994, pages 326 through 362.

For each subscriber in a mobile radio cell, respectively one time slot in one of the 124 channels is required for the upstream connection and one time slot is required for the downstream connection. One disadvantage of this method is comprised therein that a fixed transmission capacity of a time slot per transmission frame is allocated to each subscriber, this often not being utilized.

US 5,193,091 discloses a TDMA telecommunication system wherein messages are transmitted via radio channels between pico-cellular, mobile radio transmission / radio reception devices allocated to distributed pico-cells and micro-cellular, mobile radio transmission / radio reception devices allocated to micro-cell encompassing the pico-cells, said radio channels being subdivided into time slots, whereby at least one of the time slots is in turn subdivided into sub-time slots, so that micro-cellular radio transmission / radio reception devices transmit messages within the time slots and pico-cellular radio transmission / radio reception devices transmit messages in the sub-time slots, whereby the individual sub-time slots are respectively allocated to the individual pico-cells.

The invention is therefore based on the object of composing a method for digital radio transmission of data between a base station and a plurality of subscribers, whereby the transmission capacity can be flexibly divided onto various users with different data rates, for example voice communication or data communication.

This object is achieved by the digital radio transmission method defined in claim 1. Advantageous developments of the invention are described in the subclaims.

In the inventive method, the data to be transmitted between a plurality of different subscribers and the base station are transmitted in time slot frames, whereby the position of the data in time slot identifies the corresponding subscriber. On the basis of the position of a detected data symbol within a time slot received by the receiver, the subscriber recognizes whether the symbol belongs to the data sequence allocated to him. Conversely, the base station determines the subscriber or,

respectively, the mobile part from which the data are transmitted based on the position of detected data symbol. This is thus a matter of a second time-division multiplex stage within a time frame. The length of these time-division multiplex data packets, however, is variable in contrast to those of the TDMA frame.

The data of the various subscribers can be transmitted interleaved by symbols or by blocks within a time frame. Given block-by-block interleaving, subscribers who require a high transmission quality, for example for a data communication, can be transmitted in the proximity of a synchronization training sequence. The time-varying multiple path propagation paths are estimated with the assistance of a training or pilot sequence and allow a very good prediction of the

time slot comprises at least one data region. This is in turn divided into blocks composed of a plurality N of transmission data symbols of various subscribers. In the example shown in Fig. 2, the data symbols or data bits of four subscribers are arranged in one data block.

There are two different possibilities for the arrangement of the data symbols of a plurality of subscribers within a time slot:

1. Complete Interleaving:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with double the data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 5, 9, 13... N-3.

Subscriber 2 occupies the transmission data symbols 3, 7, 11, 15...N-1.

Subscriber 3 occupies the transmission data symbols 2, 4, 6, 8, 10, 12, 14, 16, ... N-2, N.

2. Block Formation:

(Example: three subscribers, subscriber 1 and 2 with data rate X and subscriber 3 with data rate 2X)

Subscriber 1 occupies the transmission data symbols 1, 2, 3,...N/4

Subscriber 2 occupies the transmission data symbols N/4+1, N/4+2,...N/2.

Subscriber 3 occupies the transmission data symbols N/2+1, N/2+2,...N.

It is clear from the examples that the data capacity can be optimally utilized by the simultaneous utilization of a data block in a time slot by a plurality of subscribers. At the same time, the available transmission capacity can be flexibly allocated. In the above examples, double the data rate of the subscribers 1 and 2 is allocated to the subscriber 3.

The position of the individual data symbols or data blocks within the time slot indicates the respective subscriber. This information can be accommodated in a control signal field in a preamble area, postamble area or the like of the time slot. Given the subscribed, block-by-block arrangement of the data symbols of various subscribers, the data of subscribers that require an especially high transmission quality can be arranged in the proximity of the training sequence (for example, subscriber 1 in the example of Fig. 2). The time-variable multi-path propagation paths are estimated

with the assistance of a training or pilot sequence and allow a very good prediction of the distortions caused by the channel for the data symbols arranged in the immediate proximity thereof. A higher dependability of the detection can thus be achieved for these data symbols than for data symbols arranged at a greater distance. This effect is initially independent of the selected detector, as long as it involves the estimate of the channel properties.

The application of the invention to CDMA-based systems with spread encoding of variable spread code length is explained in greater detail below on the basis of examples and with reference to Fig. 3. In order to also be able to advantageously use the inventive transmission method, whereby the data symbols of a plurality of subscribers are transmitted in one time slot, when the currently required data rate lies below the maximum transmission capacity, a spread of the data symbols with a spread code having a defined length of n symbols can be undertaken. In a TDMA time slot, a CDMA division is also undertaken in addition to the time-division multiplex blocks or chips. In the example shown in Fig. 3, the data of nine different subscribers are thus transmitted in 24 blocks (six time-division mulitplex blocks times four different spread codes) in one TDMA time slot, whereby between one block (subscribers 8 and 9) and four blocks (subscriber 7) are allocated to the respective subscribers. The radio transmission is less sensitive to narrow-band interference within the transmission frequency band. The transmission is only deteriorated but a total outage does not occur. Due to an adaptation of the spread code length, an adaptation to the data symbol rate requested by the subscribe can be achieved given a constantly predetermined chip rate of the transmission system (given constant transmission band width). Given a high user data rate, the spread code length is reduced and, thus, a data symbol of the user is transmitted with a lower number of chips. In order to achieve the same energy per payload bit, the transmission power is to be increased by the corresponding factor. Given a low payload data rate of the subscriber, the spread code length is increased and the power is reduced.

When a plurality of orthogonal spread codes are used that can be easily separated by the receiver, the transmission bandwidth available is utilized in the best possible way, since a total of n orthogonal spread codes with which the data symbols

of various subscribers can be transmitted in parallel are available given a spread code length of n symbols. The allocation of the data symbols to the respective subscribers thereby ensues both on the basis of the position of the symbols or, respectively, symbol blocks within a time slot as well as on the basis of the respectively selected spread code. A plurality of subscriber dat streams can thereby be simultaneously communicated in parallel with spread codes of different length that, however, are orthogonal relative to one another.

In a TDMA system, the introduction of the variable spread can avoid a pulsed mode at very low user data rates. Due to the spread, each user bit is distributed onto a plurality of "chips" and enables the interruption-free emission of the chip symbols with the predetermined clock rate of the transmission channel. The transmission power can also be reduced by the spread factor here.

Three examples of the inventive method with spread encoding are explained below. The spread code or CDMA code in the examples is composed of four symbols (1, j, -1, -j in the first and second example, whereby $j = \sqrt{-1}$). Each subscriber data symbol (bit) is expanded by the code spreading, i.e. multiplication with the spread code symbols, being expanded onto what is referred to as "chip" composed of four symbols.

Example (1): Q=4, 1 User

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18||19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1st bit	2nd bit	3rd bit	4thbit	5th bit	6th bit	***

Example (2): Q=4, Number of users = 2

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18||19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1:1	2:1	1:2	2:2	1:3	2.3	***

Example (3): Q = 4, Number of Users = 6, Number of CDMA codes = 3

Chip No.	1|2|3|4|	5|6|7|8|	9|10|11|12|	13|14|15|16|	17|18|19|20|	21|22|23|24|	
CDMA-Code	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	1 j -1 -j	***
User Data	1:1	4:1	1:2	4:2	1:3	4.3	***
CDMA-Code2	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	1 j 1 j	
Data Symbols	2:1	5:1	2:2	5:2	2:3	5:3	
CDMA-Code 3	1 -j -1 -j	1 -j -1 -j	1 -j -1 -j	1 -j -1 j	1 -j -1 j	1 -j -1 j	
Data Symbols	3:1	6:1	3:2	6:2	3:3	6:3	

In the first example, the data symbols (first bit, second bit....) of only one subscriber are transmitted in the data section of the time slot. The bits are successively multiplied by the spread code (1, j, -1, -j) and are less expanded onto four symbols that respectively form a chip that is then transmitted.

Two subscribers are present in the second example. The data symbols are respectively multiplied by the same spread code and are transmitted in alternation at successive positions within a time slot as expanded chip.

In the third example, a total of six subscribers are present. In order to offer an adequate transmission capacity, a total of three orthogonal spread codes or CDMA codes are employed. Two codes are orthogonal when their products yields zero. As a result thereof, the chips of different subscribers generated with orthogonal codes can be easily separated. In Example 3, the spread code (1, j, -1, -j) is used for the subscribers 1 and 4, the code (1, j, 1, j) is used for the subscribers 2 and 5, and the code (1, -j,-1, j) is used for the subscribers 3 and 6. The data of the six subscribers can thus be transmitted spread and time-multiplexed in the time slot. Let it be noted that symbols of four orthogonal codes exist given a code having the length n = 4, so that four times the data quantity compared to the unspread data transmission can be transported in one time slot frame given four times the bandwidth.

Figure 4 shows a schematic block diagram of the transmission path of a digital radio transmission method with reference to the example of voice communication. A voice activity detector 1 detects whether the subscriber is speaking and activates or deactivates the radio-frequency transmitter 11 in conformity

therewith. The voice signal is encoded by the encoders 1, 3, 4, and the bits are arranged in the means 5. The data are spread-encoded in the spread encoder 6, are interleaved with the interleaving means 7 and are encrypted with the encryption means 8. The encoded, interleaved and encrypted data symbols are ordered within the data region of the time slot in the time slot assembler means (burst assembler) 9. Additionally, the position information is attached to a section of the time slot. The data are modulated by the GMSK modulator and are transmitted from the RF transmitter 11 via the channel 20 to the RF receiver 11, are demodulated by the GMSK demodulator and equalizer 10'. The time slots or bursts are resolved by the burst resolver means 9', the data acquired in this way are deciphered by the deciphering means 8' and are de-interleaved by the de-interleaving means 7' . With the assistance of an inverse spread code, the data are decoded by the spread decoder circuit 6', the bits are arranged and the data are decoded by the decoders 1'; 3' and 4'. A noise suppression means 12 can be provided for voice communication.

The invention proposes a digital radio transmission method wherein the data symbols of a plurality of different subscribers are transmitted within a time slot of a time-division multiplex frame, whereby the position of the data identifies the corresponding subscriber. This enables a flexible allocation of transmission capacity to the subscribers. In one development of the inventive method, the data symbols of the various subscribers are encoded with a variable-length spread code and are thus transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

PATENT CLAIMS

1. Met hod for digital radio transmission of data between a base station and a plurality of subscribers in time slot frames, whereby the payload data of a plurality of different subscribers are transmitted in one time slot, characterized in that the position of the payload data in a time slot defines the corresponding subscriber.

2. Method according to claim 1, characterized in that the data symbols of various subscribers are transmitted within a time slot interleaved symbol-by-symbol.

3. Method according to claim 1, characterized in that the data symbols of various subscribers to be transmitted are transmitted within a time slot interleaved block-by-block.

4. Method according to claim 3, characterized in the data symbol blocks of subscribers who require a higher transmission quality are transmitted in the proximity of a synchronization training sequence.

5. Method according to one of the claims 1 through 4, characterized in that the data symbols of various subscribers to be transmitted are transmitted encoded with a spread code.

6. Method according to claim 5, characterized in that a plurality of orthogonal spread codes having variable length are employed for the simultaneous transmission of the data symbols of a plurality of subscribers.

7. Method according to claim 6, characterized in that the elements of the orthogonal spread code lie on the unit circle in the complex number plane.

ABSTRACT

Method For Digital Radio Transmission of Data of a Plurality of Subscribers

In a method for radio transmission of data of a plurality of subscribers in time-division multiplex, the data of a plurality of different subscribers are transmitted in one time slot of a time-division multiplex frame, whereby the position of the data in a time slot identifies the corresponding subscriber. As a result thereof, a flexible allocation of the transmission capacity is realized. Additionally, the data symbols can be encoded with a variable-length spread code and can thus be transmitted in a CDMA-based system with predetermined transmission bandwidth. This allows an optimum utilization of the existing transmission capacity.

Figure 3

FIG 1

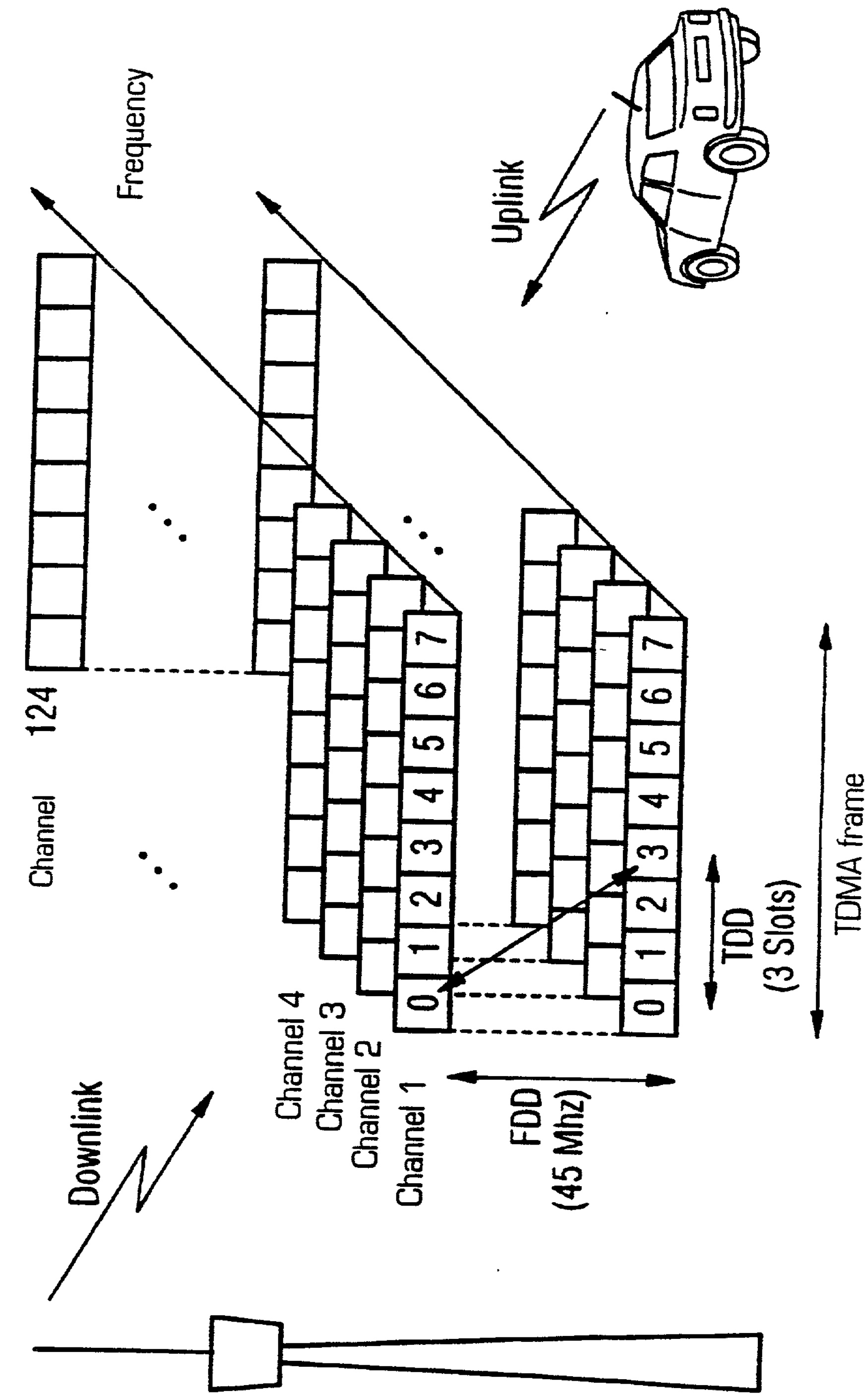
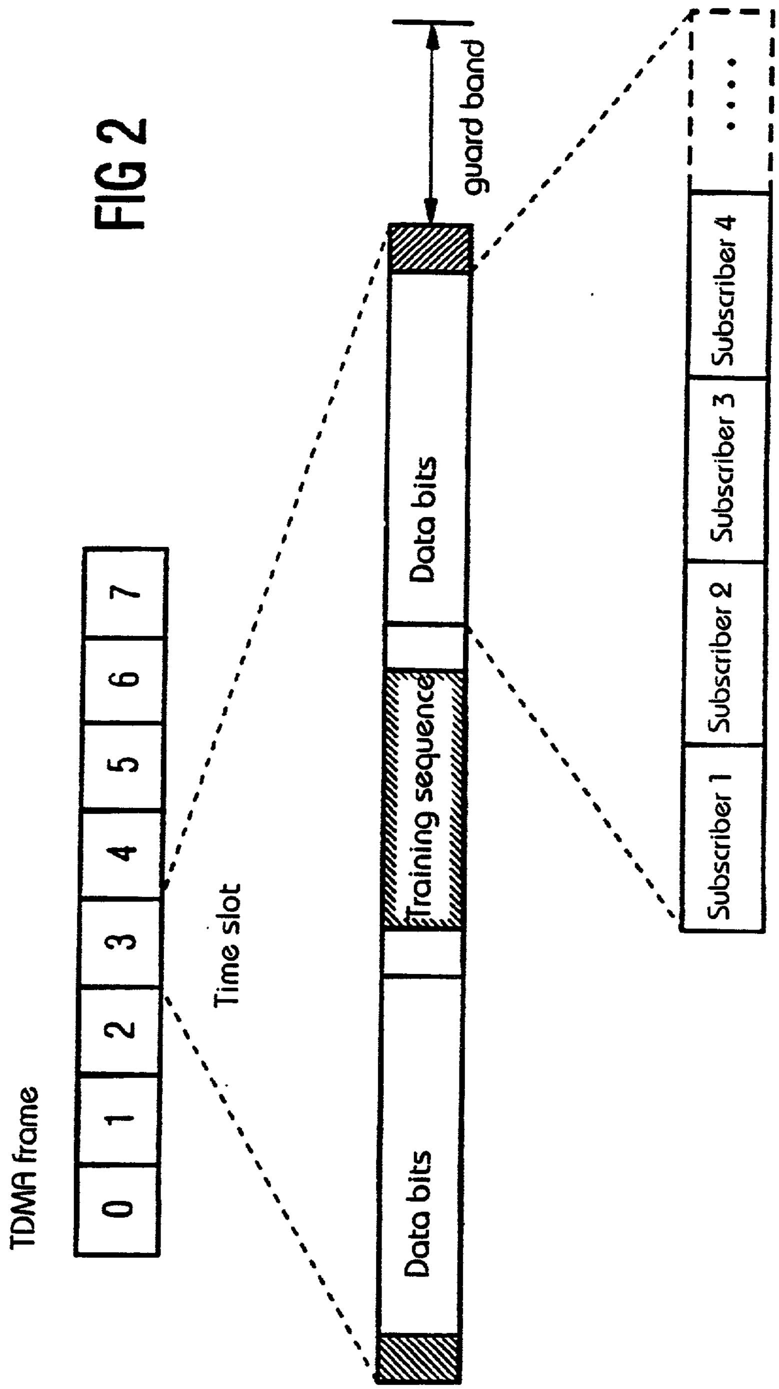

Downlink
Uplink
Frequency
Channel 124
Channel 4
Channel 3
Channel 2
Channel 1
0 1 2 3 4 5 6 7
FDD (45 Mhz)
TDD (3 Slots)
TDMA frame

FIG 2



TDMA frame
0
1
2
3
4
5
6
7
Time slot
Data bits
Training sequence
Data bits
guard band
Subscriber 1
Subscriber 2
Subscriber 3
Subscriber 4
....

FIG 3

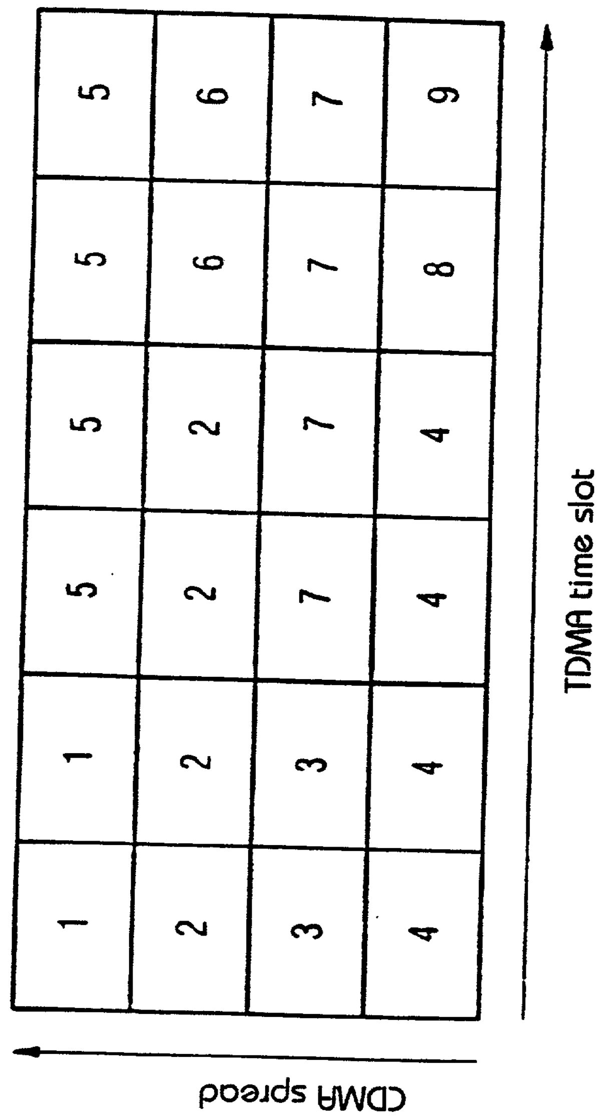
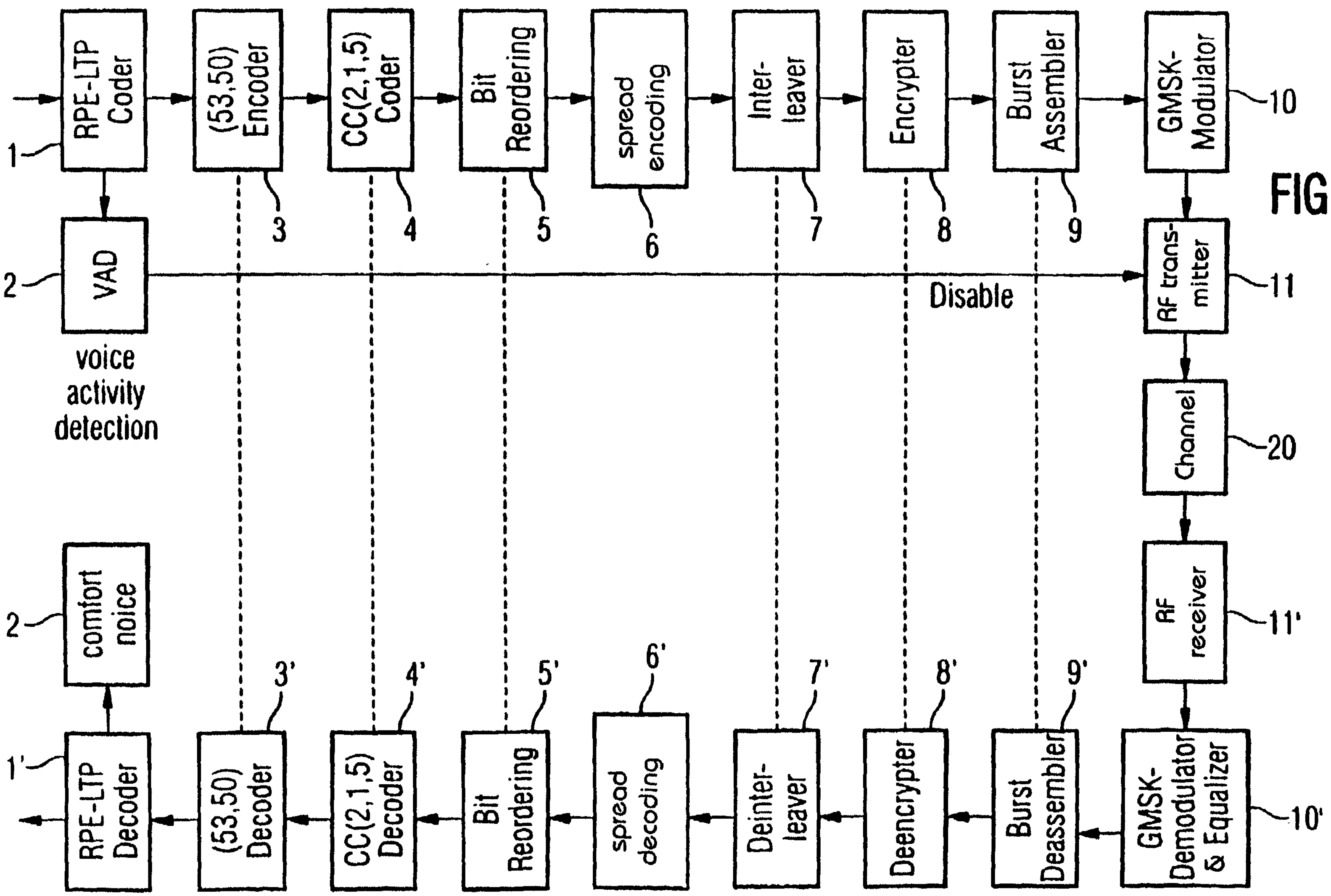


FIG 4


RPE-LTP Coder
1
(53,50) Encoder
3
CC(2,1,5) Coder
4
Bit Reordering
5
spread encoding
6
Inter-leaver
7
Encrypter
8
Burst Assembler
9
GMSK-Modulator
10
VAD
2
voice activity detection
Disable
RF trans-mitter
11
Channel
20
RF receiver
11'
GMSK-Demodulator & Equalizer
10'
Burst Deassembler
9'
Deencrypter
8'
Deinter-leaver
7'
spread decoding
6'
Bit Reordering
5'
CC(2,1,5) Decoder
4'
(53,50) Decoder
3'
RPE-LTP Decoder
1'
comfort noice
12

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION
ERKLÄRUNG FÜR PATENTANMELDUNGEN MIT VOLLMACHT
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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren zur digitalen Funk-Übertragung von Daten mehrerer Teilnehmer

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)

(check one)

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□ was filed on ________________ as
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PCT Application No. ________________
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Prior foreign applications
Priorität beansprucht

Priority Claimed

198 27 701.6	**Germany**	**22 JUNE 1998**	■	□
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			□	□
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			□	□
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein

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(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
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~~And~~ I hereby appoint Messrs. John D. Simpson (Registration No. 19,842), Steven H. Noll (28,982), Brett A. Valiquet (27,841), James D. Hobart (24,149), Melvin A. Robinson (31,870), and Mark Bergner ~~(45,877)~~), all members of the firm of Schiff Hardin and Waite.

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Wohnsitz	Residence
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

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Wohnsitz	Residence
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

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